

## 2. CLIMATE MODELING

### 2.1 INTRODUCTION

The Climate Modeling Working Group considered the requirements for radiation measurements suitable for the understanding, improvement, and verification of models used in performing climate research. Both zonal energy balance models and 3-dimensional general circulation models were considered, and certain problems were identified as common to all models. A summary of the usefulness of Earth radiation budget measurements to climate modelers is included in Appendices B and C, prepared by C. E. Leith and V. Ramanathan, National Center for Atmospheric Research, respectively. Several key areas, however, deserve special emphasis and are identified.

### 2.2 AREAS OF EMPHASIS

#### 2.2.1 Regional Energy Balance Observations

Climate studies, based on models, can benefit from regional radiation budget measurements performed on scales of about 1000 km or less. By computing the energy balance over continental regions, it will be possible to remove, or at least minimize, the uncertainties arising from ocean transport effects, which, at present, can neither be described by models, nor directly measured by oceanographic observations. Such studies, therefore, would be of invaluable aid in assessing the ability of a model to simulate present climate.

#### 2.2.2 Spectral Band Observations

Observations of selected spectral bands in both the infrared and visible spectrum would allow modelers to assess, at least under cloud-free conditions, the fidelity of calculated radiative contributions of constituents, such as H<sub>2</sub>O, CO<sub>2</sub>, O<sub>3</sub>, and aerosols separately. Such spectral band observations would provide far more valuable information than those of the total integrated radiation. Details of specific spectral intervals and a rationale for their selection are provided in Appendix C.

#### 2.2.3 Clouds and Radiation

Although cloud-radiation interaction has long been considered to be the most important source of uncertainty in all climate models, recent results indicate that the net radiation is less sensitive to clouds than was believed earlier (Cess, 1976, and Ellis, 1977). Nevertheless, considerable uncertainty remains concerning the details of how individual clouds and cloud

systems might influence the radiation budget. Such details may become important as feedback loops incorporating clouds are added to the models. Since the models will not attempt to produce the detailed structures and physical properties of clouds and cloud fields, it appears that only the statistical features, such as the probability distribution of reflectivities for a given type of cloud system, are called for in the model. However, when the spatial dimensions of clouds are considered, high resolution observations will be required, at least, to characterize the cloud fields even though the energy budget on a much larger scale is desired.

#### 2.2.4 Radiative Properties of the Surface

Determination of the radiative balance at the Earth's surface is essential to atmospheric modeling and prediction from the climatic time scales down to those scales for which radiative heating is significant. Since this balance depends directly on surface albedo and emissivity, some well-defined characteristics of albedos and emissivities must be properly and carefully determined. This determination may require statistical knowledge based on observations. Since quantities may vary with temperature and surface moisture, such changes must be computed in the models. The dependence of surface albedo and emissivity on the soil characteristics, vegetation, solar zenith angle, and cloudiness must be determined. Once such multi-parameter functions have been established on the basis of large observational samples, they may be incorporated into climate models (or other models), together with the relevant time variation of parameters in order to enhance the prediction capability of the models.

#### 2.2.5 Accuracy of Observations

At present, it appears that for validation of the relation between radiation and other model dynamics and physics, the models would benefit from an accuracy of about 5 percent for the 1000 km spatial scale and a monthly mean time scale. For checking the overall accuracy of the model simulation results for the annual energy balance cycle, however, it must be recognized that interannual variability imposes a serious limit on the accuracy of the estimation of long-term climate averages which can be improved only by longer records (Leith, 1973). It should also be recognized that to develop proper parameterization for models, one requires observations in broad-band spectral regions for cloud and surface radiative properties.

### 2.3 REFERENCES

- Cess, R. D.: Climate Change: An Appraisal of Atmospheric Feedback Mechanisms Employing Zonal Climatology. *J. Atmos. Sci.*, 22 (1976), 1831-1843.
- Ellis, James S.: Cloudiness: The Planetary Radiation Budget and Climate. Ph.D. Thesis, Department of Atmospheric Sciences, Colorado State University, Fort Collins, Colorado, 1977.
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